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Simulation of CO2 mineral trapping and permeability alteration in fractured basalt: Implications for geologic carbon sequestration in mafic reservoirs

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Basalt formations are potentially attractive targets for carbon capture and sequestration (CCS) on the basis of favorable CO2-water-rock reactions, which result in permanent CO2 isolation through mineral trapping. Recent
pilot-scale experiments in Iceland and Washington state, USA, provide promising results that indicate rapid carbon mineralization occurs within basalt reservoirs. Nevertheless, transitioning these pilot-scale results to large-scale industrial CCS operations is fraught with uncertainty because fluid flow in basalt formations is governed by fracture-controlled hydraulic properties that are highly heterogeneous and difficult to map in situ.
This uncertainty is exacerbated by feedbacks between multi-phase fluid dynamics (CO2 and water) and fluid-rock
reactions, which may result in a reinforcing feedback comprising CO2 mineralization, permeability alteration, and fluid mobility. To begin to understand the feedbacks between multi-phase fluid flow and mineralization in
fractured basalt, this study uses reactive transport simulation methods to model CO2 infiltrating a meter-scale, synthetic basalt fracture overlying a storage reservoir while accounting for porosity change due to mineralization
and its corresponding effect on permeability and fluid mobility. Results show that (i) carbonate and clay mineralization tends to occur downgradient of a fracture intersection, (ii) mineralization reduces porosity, which
leads to permeability reduction and slows free-phase CO2 migration, (iii) stronger porosity-permeability coupling
increases the proportion of mineralized carbon while reducing CO2 mass that can enter fracture, which may lead
to self-sealing behavior as fluid mobility approaches nil, and (iv) errors caused by unknown porositypermeability
relationships are small in comparison to errors that arise by omitting mineralization-induced
permeability reduction when simulating CO2 sequestration scenarios in basalt reservoirs.

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References

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Participation

Online

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